Einstein's coefficients and the wave-particle duality in the theory of thermal radiation

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Abstract

It is shown that the concept of elementary resonator in the theory of thermal radiation implies the indivisible connection between particles (photons) and electromagnetic waves. This wave-particle duality covers both the Wien and Rayleigh-Jeans regions of spectrum.

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The induced origin of thermal radio emission follows from the relations between Einstein's coefficients for a spontaneous and induced emission of radiation [1] (and references therein). The strong argument in a favor of an induced origin of thermal black-body radiation is that the spectral energy density in the whole range of spectrum is described by a single Planck's function. So if thermal radio emission is stimulated, then thermal radiation in other spectral regions also should have the induced character.

According to this conception, thermal emission from non-uniform gas is produced by an ensemble of individual emitters. Each of these emitters is an elementary resonator the size of which has an order of magnitude of mean free path l of photons, $l = 1/n\sigma$, where n is the number density of particles and σ is the absorption cross-section.

The emission of each elementary resonator is coherent, with the wavelength $\lambda = al$, where a is a dimensionless constant, and thermal emission of gaseous layer is incoherent sum of radiation produced by individual emitters.

An elementary resonator emits in the direction opposite to the direction of the density gradient. The wall of the resonator corresponding to the lower density is half-transparent due to the decrease of absorption with the decreasing gas density.

An elementary resonator can be considered as a realization of the wave-particle duality. The wavelength of radiation emitted by a resonator is determined by its size. On the other hand, the size of an elementary resonator is determined by the mean free path of photons. Thus, electromagnetic waves and particles (photons) are indivisibly tied each with other in the concept of elementary resonator.

This conclusion is contrary to the Einstein's opinion that the energy fluctuations of thermal black-body radiation can be attributed to the particles (photons) in the Wien region of spectrum, and to the waves in the Rayleigh-Jeans region [2]. The last statement has been obtained by application of the relation between the probability and entropy, the universal validity of which is a subject of ongoing debate [3].

[1] F.V.Prigara, Astron. Nachr., **324**, No. S1, 425 (2003).

[2] M.J.Klein, *Einstein and the wave-particle duality*, Natural Philosopher, No. 3 (1964).

[3] V.Erofeev, in 12th International Congress on Plasma Physics, 25-29 October 2004, Nice, France, E-print archives, physics/0409141.

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